MULTIPHYSICS MODELING OF A MINIMALLY INVASIVE TISSUE ABLATION METHODOLOGY

Joshua Thomas, Research Engineer, AltaSim Technologies
130 East Wilson Bridge Road Suite 140
Columbus, OH 43085
(614) 861-7015 x12
josh@altasimtechnologies.com

Kyle Koppenheofer, Principal, AltaSim Technologies
130 East Wilson Bridge Road Suite 140
Columbus, OH 43085
(614) 861-7015
kyle@altasimtechnologies.com

KEYWORDS

multiphysics, large deformation, tissue ablation, Joule heating, electrode, contact modeling

ABSTRACT

Tissue ablation represents a common therapeutic medical procedure to destroy diseased tissue. Thermal ablation methods achieve tissue necrosis by reaching temperatures typically below -40°C or above +50°C. A number of different thermal ablation approaches are available; however, optimizing the design of ablation electrodes and generators is complicated by the difficulty of performing *in vivo* studies. Variability in human or animal tissue, thermal dissipation by perfusion and blood flow and the complexity of tissue response can make *in vivo* approaches difficult to use with a high degree of predictability. For these reasons, computational analysis is being used to an increasing degree to simulate device performance and enable development of safer operating procedures and instrument designs.

For the class of thermal ablation problems considered, accurate analyses require including several factors that have a significant effect on the efficiency of thermal transfer. Mechanical contact must be maintained between the ablation electrode and the site of interest, excessive force may induce local deformation that affects the efficacy of the treatment due to the low elastic moduli found in tissue. Thermal dissipation mechanisms associated with local perfusion or circulation of blood will also affect the ability to reach the desired temperature.

To adequately capture these important parameters in a computational simulation of thermal ablation, a three-dimensional computational model of the Joule heating caused by an electrode in a flowing fluid has been developed using an intimately coupled, multiphysics-based approach. A current carrying electrode undergoes Joule heating, the electrode is pressed against the wall of a deformable vessel through which blood flows. Under the applied force the wall of the vessel deforms and the changing contact between the electrode and the vessel wall affects thermal transfer through the vessel wall to the underlying tissue. Figure 1 shows an example of results obtained from the three-dimensional model for elastic displacements, fluid flow, electric potential, and temperature.

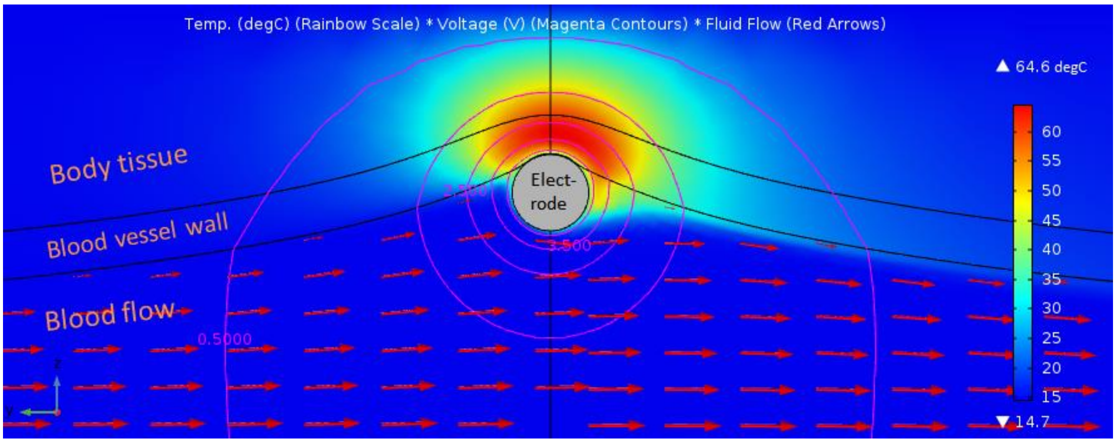

Figure 1: Example of a multiphysics simulation of a thermal ablation electrode in contact with the wall of a blood vessel through which blood flows.

The fully-coupled model has been used to isolate the effect of critical variables on the successful operation of the ablation device.